



## HEATING DRYING INFRARED RADIATION MOISTURE METER

### FIELD OF THE INVENTION

[0001] The present invention relates to a heating drying type infrared radiation moisture

5 meter for carrying out performing determination of the moisture content of, for example, grain.

### BACKGROUND

[0002] A conventional exemplary heating drying type infrared radiation moisture meter will be described with reference to FIG. 7.

10 [0003] With a conventional exemplary heating drying type infrared radiation moisture meter as shown in FIG. 7, a load meter 35 is disposed ~~in the~~ inside of a box-like cabinet 38, and at ~~the~~an upper end of a weighing column 35a for this load meter 35, a saucer 34 and a sample plate 31 for placing a sample thereon are mounted.

15 [0004] Above the cabinet 38, a reflecting plate 36 and a lower windscreens 32b are fixed such that they surround the weighing column 35a, and above the lower windscreens 32b, an opening and closing type upper windscreens 32a is disposed such that it surrounds the sample plate 31.

20 [0005] ~~In the inside~~ Inside of the ~~above mentioned~~ upper windscreens 32a, an infrared lamp 33 and a temperature sensor 37 using a thermistor are disposed. By means virtue of the infrared lamp 33, a sample on the sample plate 31 is irradiated with infrared radiation to heat ~~it~~ the sample for evaporating ~~the~~ moisture contained in the sample, and ~~the~~a weight of the sample is measured to perform ~~the~~a prescribed calculation for determining the moisture content of the sample.

[0006] The temperature sensor 37 detects ~~the~~a sample temperature for on/off control of

the infrared lamp 33.

[0007] With a conventional exemplary heating drying type infrared radiation moisture meter as shown in FIG. 7, it is originally ideal that ~~the-a~~ surface temperature of the sample is detected by the temperature sensor 37, however, ~~it~~this is actually difficult.

5 [0008] ~~The-A~~ temperature detected by ~~said-the~~ temperature sensor 37 is neither ~~the-a~~ temperature of the infrared lamp ~~or-nor~~ the surface temperature of the sample. In detail, the temperature detected by ~~said-the~~ temperature sensor 37 is a combination of ~~the-a~~ temperature of ~~the-so-called~~ radiant heat, which is as a result of the temperature sensor 37 itself absorbing ~~the~~ infrared radiation emitted from the infrared lamp 33, ~~and an~~ ~~with the~~ ambient temperature in the 10 chamber formed by the upper windscreens 32a.

15 [0009] In this case, if ~~the-a~~ relationship between the temperature detected by the temperature sensor 37 and the temperature of the sample surface is always constant, there arises no problems. In other words, if the temperature sensor 37 can precisely detect ~~the-a~~ temperature, the temperature of the sample surface can also be precisely controlled. However, actually, such a relationship is not always constant for the following reasons:

[0010] (1) ~~The relative~~ Relative distances among the infrared lamp 33, the temperature sensor 37, and the sample surface ~~to-one-another~~ may vary from unit to unit, which results in a multiple error.

20 [0011] For example, if ~~the-a~~ distance between the infrared lamp 33 and the temperature sensor 37 is shorter than ~~the-a~~ specified one distance, ~~the-an~~ energy density of ~~the~~ infrared radiation in the vicinity of the temperature sensor 37 is higher than ~~the-a~~ specified value, ~~the~~ and a temperature of the temperature sensor 37 reaches ~~the-a~~ setting temperature at a higher speed; thus, the infrared lamp itself is controlled at a value lower than ~~the-a~~ desired value, which causes ~~the-a~~ surface temperature of ~~the-a~~ sample to be controlled at a lower value.

[0012] (2) An error due to the-a difference in the-ambient temperature in the chamber at the-a start of measurement may be produced.

[0013] In detail, the-an ambient temperature in the chamber at the-a start of measurement for the-a first time in a particular day is near the-room temperature; however, the-an ambient 5 temperature in the chamber at the-a start of measurement for the-second and third times is raised under the-influence of the-measurement for the last a previous time. In addition, the-a value of increase in temperature may vary. Such a difference in temperature between ordinal numbers of measurement may cause an error.

[0014] Specifically, as shown in FIG. 8, assuming that the-a control temperature is set at 10 120°C, and the-a temperature of the temperature sensor at the start of measurement for the first time is 25°C, the temperature of the temperature sensor at the start of measurement for the second time would be 70°C, which would result in the-a required time period of heating (full-power heating) by the infrared lamp 33 for the first time of measurement being "a", compared to "b" for the second time of measurement, which would create a difference in the-a 15 dried condition between samples sequentially placed on the sample plate 31.

[0015] (3) A difference in color between samples may produce an error.

[0016] With said-the conventional exemplary heating drying type infrared radiation moisture meter as shown in FIG. 7, the infrared lamp 33 is controlled such that the temperature of the temperature sensor 37 is constant, and the-a difference in color between samples have-has 20 not been considered. However, actually, if the color is different between samples, the-an absorption factor will also differ from sample to sample, and thus if the temperature of the temperature sensor 37 is kept constant, an error due to the-a difference in surface temperature between samples may be caused.

[0017] The present invention has been developed in consideration of the above stated

conventional situation, and is intended to provide a heating drying type infrared radiation moisture meter which allows a precise measurement of the moisture content of the a sample to be carried out performed independently of the an ambient temperature in the chamber at the a start of measurement, with no errors due to a difference in color between samples being produced.

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## SUMMARY OF THE INVENTION

Here is a summary of the present invention.

[0018] The present invention provides:

[0019] [1] A a heating drying type infrared radiation moisture meter which detects the a 10 temperature of a heated and dried sample by using a temperature detection means-device for carrying out performing moisture content determination, wherein said the temperature detection means-device is configured with a radiation thermometer which carries out performs infrared radiation detection;:

[0020] [2] The the heating drying type infrared radiation moisture meter according to 15 [1], wherein said the radiation thermometer is disposed just above, aslant above, just under, or aslant under a sample plate, which is a component of said the heating drying type infrared radiation moisture meter, with a definite separation from a sample on the sample plate being provided;:

[0021] [3] The the heating drying type infrared radiation moisture meter according to 20 claim 1 [1], wherein said the radiation thermometer is disposed in a location where it is permitted to receive infrared radiation which is conducted through a light conducting member disposed above a sample plate, which is a component of said the heating drying type infrared radiation moisture meter;:

[0022] [4] The the heating drying type infrared radiation moisture meter according to

any one of the items-[1] to [3], wherein said the radiation thermometer is covered with includes a cover of a heat insulating material.:;

[0023] [5] The the heating drying type infrared radiation moisture meter according to any one of the items-[1] to [4], wherein the-a light receiving portion of said the radiation thermometer is provided with a removable clear protection cover.:;

[0024] [6] The the heating drying type infrared radiation moisture meter according to any one of the items-[1] to [5], wherein a heating reference element for carrying out performing temperature calibration of the radiation thermometer is removably disposed inside of said the sample plate.:;

[0025] According to the invention as defined in the above items-[1], [2], and [4] to [6], the heating drying type infrared radiation moisture meter is configured by using a radiation thermometer carrying out for performing infrared radiation detection as the temperature detection means device, which allows for a precise measurement of the-moisture content of the sample independently of the-an ambient temperature in the-a chamber at the-a start of measurement, with no errors due to a difference in color between samples being produced.

[0026] In other words, the-infrared radiation emitted from the-a surface of the sample is detected by the radiation thermometer (the-an average detection wavelength ranging from 6.4 to 14μm) to be subjected to signal processing for determining the-a surface temperature of the sample,thus. Thus, an advantage of that, if the relative distances of the-a heater, the temperature sensor radiation thermometer, and the-sample surface relative to one another are changed, no errors as mentioned in the description about of the conventional exemplary heating drying type infrared radiation moisture meter will be produced, is offered.

[0027] In addition, because the surface temperature of the sample is detected with the-use of the radiation thermometer, the-a difference between the ambient temperature in the chamber

(in the-an upper windscreen) at the start of measurement for the-a first time and that at the start of measurement for the-a second time can have no effect on the result results of measurement, thereby producing no errors as mentioned in the description of said-the conventional exemplary heating drying type infrared radiation moisture meter.

5 [0028] Further, because the radiation thermometer utilizes an-infrared radiation having an average wavelength of 6.4 to 14μm, no light having a wavelength in the-a band of the-a visible light region will be detected, which results in no measurement errors due to a difference in color between samples being caused.

[0029] Further, said-the radiation thermometer is covered with includes a cover of a heat insulating material, and thus the-an effect of the-ambient temperature is more reliably eliminated; and a high degree of freedom in disposition of the radiation thermometer is provided. A; a clear protection cover is provided, and thus the-substances evaporated from the sample and the like can be prevented from getting in entering the radiation thermometer, while the clear protection cover can be freely replaced with a new one. And, ; and a heating reference element for carrying 15 out performing calibration is provided, and thus the-temperature calibration can be easily performed.

[0030] According to the invention as defined in the item-[3], the-functional effects of the inventions as defined in the items-[1], and [4] to [6] are provided, while said-the radiation thermometer can be disposed in a lower-temperature environment, and thus the-an effect of the 20 ambient temperature can be eliminated still more reliably.

[0031] [7] A-a heating drying type infrared radiation moisture meter which detects the-a temperature of a sample heated and dried on a sample plate by using a temperature detection means-device for carrying out performing moisture content determination, wherein said-the temperature detection means-device is a radiation thermometer which includes a cover of is

~~eovered with a heat insulating material, being disposed just above, aslant above, just under, or aslant under the sample plate with a definite separation from a~~ the sample on the sample plate being provided, and ~~which has~~ light receiving portion is provided with a removable clear protection cover, and wherein a heating reference element for carrying out performing temperature calibration of the radiation thermometer is removably disposed inside of ~~said~~ the sample plate.

[0032] According to the invention as defined in ~~the item~~ [7], a heating drying type infrared radiation moisture meter which can provide the functional effects of the inventions as defined in ~~the items~~ [1], [2], and [4] to [6] as a whole can be offered.

[0033] [8] A a heating drying type infrared moisture meter which detects the temperature of a sample heated and dried on a sample plate by using a temperature detection means device for carrying out performing moisture content determination, wherein: ~~said~~ the temperature detection means device is a radiation thermometer which includes a cover of ~~is eovered with a~~ heat insulating material; ~~which~~ a light receiving portion is provided with a removable clear protection cover; and ~~which~~ the radiation thermometer is disposed in a location where it is permitted to receive infrared radiation which is conducted through a light conducting member disposed above ~~a~~ the sample plate; and a heating reference element for carrying out performing temperature calibration of the radiation thermometer is removably disposed inside of ~~said~~ the sample plate.

[0034] According to the invention as defined in ~~the item~~ [8], a heating drying type infrared radiation moisture meter which can provide the same functional effect of the invention as defined in ~~the item~~ [3] can be offered.

## BRIEF DESCRIPTION OF THE DRAWINGS

- [0035] FIG. 1 is a schematic drawing showing the-a general configuration of a heating drying type infrared radiation moisture meter according to the present embodiment invention;
- [0036] FIG. 2 is a schematic plan view of only the-an upper windscreen of a heating 5 drying type infrared radiation moisture meter according to the present embodiment invention;
- [0037] FIG. 3 is a plan view of a radiation thermometer according to the present embodiment invention;
- [0038] FIG. 4 is a sectional view of a radiation thermometer according to the present embodiment invention;
- 10 [0039] FIG. 5 is an explanatory drawing showing the-a configuration of a heating reference element according to the present embodiment invention;
- [0040] FIG. 6 is a schematic sectional view showing the-a critical portion of a modification of the heating drying type infrared radiation moisture meter according to the present embodiment invention;
- 15 [0041] FIG. 7 is a schematic configuration drawing showing a conventional exemplary heating drying type infrared radiation moisture meter; and
- [0042] FIG. 8 is an explanatory drawing showing the-time periods required for heating an infrared lamp at the-a start of measurement for the-a first time and that for the-a second time with a-the conventional exemplary heating drying type infrared radiation moisture meter.

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## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

- [0043] Hereinbelow, an embodiment of the present invention will be described in detail with reference to the drawings.
- [0044] FIG. 1 shows a heating drying type infrared radiation moisture meter according to

an embodiment of the present invention. ~~In the inside~~ Inside of a box-like cabinet 1, a load meter 2 for measuring ~~the-a~~ weight of a sample is disposed, and at ~~the-an~~ upper end of a weighing column 2a, a saucer 3, for example, and a sample plate 4 for placing a sample thereon, such as grain, is are mounted.

5 [0045] In ~~the-an~~ upper portion of the cabinet 1, a lower windscreens 5 is fixed such that it surrounds the saucer 3 at the upper end of the weighing column 2a and the sample plate 4.

[0046] Above the lower windscreens 5, a cylindrical upper windscreens 6, which is opened at ~~the-its~~ bottom, and can be opened and closed, is disposed. ~~In the inside~~ Inside of this windscreens 6, a pair of heaters 7 for heating the sample is mounted in parallel with ~~the-a~~ top of 10 the sample plate 4.

[0047] At ~~the-an~~ edge of said ~~the~~ upper windscreens 6, a radiation thermometer 10, as a temperature detecting means-device that is capable of detecting ~~an~~-infrared radiation (with an average wavelength of 6.4 to 14 $\mu$ m), which is described later in detail, is disposed aslant above the sample plate 4.

15 [0048] In FIG. 1, a cover to be disposed above the cabinet 1 is indicated at 8, and a control panel for carrying out performing various operations is indicated at 9.

[0049] The heating drying type infrared radiation moisture meter according to the present embodiment is configured such that the sample is heated by ~~said-the~~ pair of heaters 7 for evaporating ~~the~~-moisture contained therein, ~~the-a~~ value of ~~the~~ change in weight of the sample that 20 is determined through the load meter 2 being-is fed to a data processing section 13 through an amplifier circuit 11 and an A/D converter 12, and the data processing section 13 performing the performs a prescribed calculation using ~~the-a~~ value of the weight before heating the sample for determining ~~the-a~~ value of ~~the~~-moisture content, which is displayed by a display section 14, such as a liquid crystal display.

- [0050] The A temperature detected by said the radiation thermometer 10 and the a result of the calculation performed by the data processing section 13 are fed to a control section 15, which uses these values for performing heating control of said the pair of heaters 7.
- [0051] Said-The amplifier circuit 11, A/D converter 12, data processing section 13, 5 display section 14, and control section 15 are actually loaded in the cabinet 1 (the display section 14 being provided in the control panel 9).
- [0052] FIG. 2 is a plan view showing only said-the upper windscreens 6 in a perspective manner, and this upper windscreens 6 is provided with support arms 16 for opening and closing operations that are not shown in FIG. 1.
- 10 [0053] On said-the sample plate 4, a heating reference element 17 for temperature calibration, that is described later, is disposed.
- [0054] Next, with reference to FIG. 3 and FIG. 4, the radiation thermometer 10 will be described in detail.
- [0055] With this radiation thermometer 10, a body 21 which is in the-a shape of a 15 rectangular prism, and a loading cylindrical portion 22 which is projected from one end of the body 21 are integrally configured, and by loading the loading cylindrical portion 22 in-into a loading hole 6a provided aslant at the-an edge of said-the upper windscreens 6, the radiation thermometer 10 is disposed, for example, aslant above the sample plate 4 in the embodiment as shown.
- 20 [0056] The radiation thermometer 10 can be disposed not only aslant above the sample plate 4, but also, for example, just above, just under, and aslant under the sample plate 4, with a definite separation from the sample being provided. However, when radiation thermometer 10 is disposed just under or aslant under the sample plate 4, the-a surface temperature of the sample is detected through the sample plate 4 rather than directly,-; and thus, it is preferable that the-a

heat capacity of the sample plate 4 itself be reduced for minimizing ~~the~~an effect of the sample plate 4. To reduce the heat capacity of the sample plate 4, the sample plate 4 may be formed by using a material, such as an aluminum foil, which is thin and good in terms of thermal responsiveness.

5 [0057] At ~~the~~a projection end of saidthe loading cylindrical portion 22, a light receiving opening 23 is provided, and inside thereof, a detector section 24 is disposed. ~~In~~the inside Inside of the body 21, a thermometer circuit board 25, on which an electronic circuit for operating saidthe detector section 24 and compensating for ~~the~~a temperature drift, is fixed.

10 [0058] Said The loading cylindrical portion 22 is formed by using a heat insulating material which is ~~excellent~~excellently adiathermic, and at the end of the loading cylindrical portion 22 outside the light receiving opening 23, a cap 27 and a removable clear protection cover 26 which is intended to prevent ~~the~~ substances evaporated from the sample, and the like from getting inentering the radiation thermometer 10 is provided. The clear protection cover 26 can be freely replaced with a new one.

15 [0059] FIG. 5 is a view showing thea configuration of the heating reference element 17, and the heating reference element 17 in the embodiment as shown is made of aluminum, being colored black or white, and configured by embedding a reference thermometer 19 (a thermocouple) in a circular disk 18 which is subjected to a surface treatment of alumite (anodizing).

20 [0060] Thetemperature Temperature calibration using the heating reference element 17 is carried outperformed by placing the heating reference element 17 on the sample plate 4, for example, and using the said control panel 9 for setting thea temperature calibration mode at thean automatic calibration mode to match thea temperature of the heating reference element 17 (thea reference temperature) to thea detection temperature of the radiation thermometer 10.

The temperature Temperature calibration is performed at each of the temperatures of 80°C, 100°C, 120°C, and 150°C, for example.

[0061] Because the operation of the radiation thermometer 10 is such that the detector section 24 of the radiation thermometer 10 detects the infrared radiation emitted from the a 5 surface of the sample (the an average detection wavelength ranging from 6.4 to 14μm) to subject it to signal processing for determining the a surface temperature of the sample, the heating drying type infrared radiation moisture meter according to the present embodiment offers an advantage of that, if the relative distances of the heater heaters, the temperature sensor radiation thermometer, and the sample surface relative to one another are changed, no errors as mentioned 10 in the description about of the conventional exemplary heating drying type infrared radiation moisture meter will be produced.

[0062] In addition, because the surface temperature of the sample is detected with the use of the radiation thermometer 10, the a difference between the ambient temperature in the chamber (in the upper windsreen 6) at the a start of measurement for the a first time and that at 15 the a start of measurement for the a second time, for example, can have no effect on the a result of measurement, thereby producing no errors as mentioned in the description of said the conventional exemplary heating drying type infrared radiation moisture meter.

[0063] Another advantage is such that, because the radiation thermometer 10 utilizes an infrared radiation having an average wavelength of 6.4 to 14μm, no light having a wavelength in 20 the a band of the a visible light region will be detected, which results in no measurement errors due to a difference in color between samples being caused.

[0064] Next, with reference to FIG. 6, the a critical portion of a modification of the heating drying type infrared radiation moisture meter according to the present embodiment will be described.

[0065] In the modification as shown in FIG. 6, the-radiation thermometer 10 is disposed in the-an area outside the-upper windscreen 6 that-which provides a lower-temperature environment, instead of being disposed as shown in FIG. 1.

[0066] In detail, the radiation thermometer 10 is fixed being disposed in the vicinity of 5 the upper windscreen 6 with a clear glass plate 28 being mounted in the-a central portion of the-a top of the windscreen 6, and thereabove, a mirror 29 as a light conducting member being-is fixed in the-an inclined position at an angle of 45° deg for folding the deflecting a path of the-infrared radiation from the-a sample at an angle of 45°-deg, and directing the mirror 29 radiation toward the-light receiving opening 23 of the-mirror 29 radiation thermometer 10. The other Other 10 configurations of this modification is-are the same as those of the heating drying infrared radiation moisture meter as shown in FIG. 1.

[0067] According to this heating drying type infrared radiation moisture meter as a modification, the-an effect of the-ambient temperature in the upper windscreen 6 can be eliminated still more reliably in addition to the above stated functional effects, because the 15 radiation thermometer 10 is disposed in the-an area which provides a lower-temperature environment. As a light conducting member, an optical fiber may be used in place of the mirror 29.

[0068] According to the present invention, a heating drying type infrared radiation moisture meter can be provided which allows a precise measurement of the-moisture content of 20 the-a sample to be carried-out performed independently of the-ambient temperature in the-a chamber at the-a start of measurement, with no errors due to a difference in color between samples being produced.

[0069] Further, a heating drying type infrared radiation moisture meter can be provided which eliminates the effect of the-ambient temperature more positively, offers a high degree of

freedom in disposition of the radiation thermometer, permits said a clear protection cover for the radiation thermometer to be freely replaced with a new one, while allowing ~~the~~ substances evaporated from ~~the~~a sample and the like to be prevented from ~~getting in~~ entering the radiation thermometer, and makes it easy to perform ~~the~~ temperature calibration.

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## ABSTRACT OF THE DISCLOSURE

A heating drying type infrared radiation moisture meter which detects the a temperature of a sample heated and dried on a sample plate 4 by using a temperature detection means-device for carrying out performing moisture content determination, wherein said the temperature 5 detection means-device is a radiation thermometer, ~~10~~ which includes a cover of ~~is covered with~~ a heat insulating material, being disposed aslant above the sample plate 4 with a definite separation from a sample on the sample plate 4 being provided, ~~and which~~. A light receiving portion is provided with a removable clear protection cover ~~26~~, and a heating reference element ~~17~~ for carrying out performing temperature calibration of the radiation thermometer ~~10~~ is 10 removably disposed inside of said the sample plate 4.